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DEPARTMENTAL CONFERENCES.

BIOLOGY.

The subject announced for consideration was: "What Phases of Botany and Zoölogy Should Be Emphasized in Secondary Instruction?"

The subject was presented from the standpoint of botany by Professor O. W. Caldwell, of the State Normal School at Charleston, in a paper upon the

ESSENTIALS OF HIGH-SCHOOL BOTANY.

A detailed plan for a course in botany cannot be completely adapted to the use of any two schools, nor for the work of one school during consecutive years. Visitation of high schools, correspondence, and reading of educational literature will soon convince one, however, that in the best high schools the courses in botany that are based upon the same sort of interpretation as to essentials have ample individuality. One will be convinced further of the fact that there are wide differences in ideas as to just what the course in botany should include. Among high schools of lower grade in quality of work done, in general, there is likely to be found less variation either in individuality of work, or in the prevailing notions as to what should constitute the course. In such schools the work is usually chiefly text-book work, and since but few of the so-called standard texts lend themselves readily to a purely text-book course, less variation is presented in schools of this class. The teacher in schools of this grade is usually less conspicuous as a variable element, on account of his more limited knowledge of the subject, and consequent greater dependency upon the text-book.

In teaching, as in any other business, the ends sought should determine the materials used and the treatment administered.

Any artisan to be successful must select his materials and determine his method of treatment of those materials with reference to the sort of structure that he wishes to build. The course in botany should recognize the values that should come from the proper study of plants, and should adjust itself to the development of these things. The first one of these values that comes from the proper presentation of this as well as from other sciences, is the scientific habit of thinking. So many good statements, differing considerably however, have been made in various places by different persons concerning the scientific habit of mind that an attempt at a full exposition of this prime result to be obtained from a course in science need not now be made. A brief review of the more important features of the scientific mind will suffice. The student of truly scientific training holds that it is through truth only that educational or spiritual freedom is to be found. The truth is desired above all things. The integrity of one's mind is to be maintained only by the most willing and ready exposure of one's notions to any new evidence, regardless of whether this evidence is favorable or counter to the beliefs previously held. Withholding one's conclusions from one set of evidences and exposing them to another set is distinctly contradictory to the scientific method. Mere exposure to science does not always confer this method. The claim may be made with justice that many so-called scientists are most unscientific. Many of our research workers have undertaken a piece of work, not to see whether a certain disputed conclusion be true, but to prove that it is true. Oftentimes do we have excellent papers appearing, being based upon phenomena that have been under the eye of other observers many times, but which were not seen because those particular phenomena were not being sought. Some such things must necessarily occur, due to the nature of our limitations.

The scientific mind can wait. Judgments are not so necessary as it is that they be correct in case we have them. The scientific imagination does forecast a judgment, it is true, when some evidence has been observed, but it is left for accumulating evidence to test the validity of forecast. The scientific mind

must be alert for those phenomena that bear in any way on questions in hand.

Clear expression develops along with clear thinking, since each complements the other. The expressing of what one observes has advantage over a similar act for that about which he has read, since in the former his own words alone must suffice for conveying his thoughts. Logical observation should always be followed by brief but comprehensive description. The scientific mind speaks clearly, concisely, logically, and neatly.

The methods of thinking inculcated by proper scientific training should help to protect their possessors from many physical and ethical errors. Any good course in science must help establish the law of causation. A well-grounded working belief in the fact that causes of necessity must have their results, and results their causes, will do much to remove the still rather popular notion that we can go counter to natural and ethical laws, and in some way escape from the logical results. I do not believe that literature or history, or any other subject in our curriculum, furnishes any one thing that is more potent in making a high type of manhood than is this law of causation as taught in the true methods of science.

It should be mentioned that the possession of the scientific method in one field does not prove necessarily that it will be employed when the possessor enters another field. Men of scientific training frequently make themselves ridiculous by going into fields in which they have done no definite study, and giving utterance to statements indicating that not only have they deserted their field, but their method of thinking as well. Hence the necessity of a reasonably thorough course, in several of the sciences—physics, zoölogy, botany, chemistry. The student should learn to apply the method of thinking to several fields of science and to other fields as well. The scientific method is no longer peculiar to science. It is applicable and largely used in various other lines of study.

As a general value to be obtained from a study of botany there should be developed as wide a knowledge of plants and the fundamental principles of the plant kingdom as the length

of the course and development of the pupils make possible. The two fundamental processes of nutrition and reproduction should always be recognized quite early in any general course. Plants exist for the performance of these two functions. Each organ is so adjusted as to have some relation to one or both of these pieces of work, and plants differ among themselves just as their adjustments in structure and habit differ with reference to the solution of these two problems. Between different great groups of plants there are quite wide differences in the ways in which nourishment is obtained and in which new individuals are established. These group differences in structure, as adjusted to work, are such as to establish, in a general way, type-forms for each great group, as mosses, ferns, or flowering plants. Such group-types may be recognized and the general significance of parts understood by a student in a fairly brief course. It is not a difficult matter for this student, though a beginner, to arrange these groups according to their order of complexity, and to have a definite appreciation for the facts in these adjustments in structure that cause the groups to be arranged thus.

There are many variations, however, within the group, and one no sooner studies several members of the group than he finds that there is a more or less well-marked gradation in complexity within it. When he has studied two or more groups, and has arranged them and the various forms representing them in order of complexity, he discovers that as much of the plant kingdom as he has observed is arranged with reference to adaptation to nutrition and reproduction in a series running from quite simple to quite complex. Completion of study of all groups more firmly establishes his notion of this relation as to complexity.

Not all of our high-school students can see the evolutionary significance of this portion of our botany work. There is little doubt in my mind that in some high schools the evolutionary study of plants has resulted in extremely poor returns for both student and botany. But certainly it is true that the structure of plants should be studied with reference to nutrition and

reproduction; that all students will recognize wide differences in these respects between groups, and less marked differences between more closely related individuals; and, further, that the best students will obtain a fairly accurate and very helpful conception of the evolution of plants.

The knowledge of plants to be obtained should be wide enough to make the pupil conversant with the leading physiological processes, and with the leading adjustments in form that assist in performing these processes under various physiological conditions. Associated with this should be a knowledge of the fact that plants are not static, but constantly exhibit variations in habits and structure; and, following these facts, some will obtain a knowledge of the general problem of evolution. There should be obtained considerable knowledge of the relations of plants to man, much of this knowledge coming in a merely incidental way. A speaking acquaintance with a considerable number of individual species of plants is highly desirable.

A third general value that the study of botany should give is that of culture. The time has passed when we believed that students wishing especially to become cultured should study Latin and Greek, while those who could not afford to become cultured should content themselves with the study of the sciences. The cultural value of the proper study of botany is not in danger at present of being overestimated. To have the qualities of mind given through the proper study of botany, or any science, to have the first-hand knowledge of, and interest in the life of things about us, certainly contributes to general culture. But to claim that all persons may attain their highest degree of culture from any subject, or group of subjects, assumes a uniformity of human beings that by no means exists. Each may obtain his highest culture possibilities by pursuing his own most culture-producing subject, at the same time maintaining his intelligent interest and sympathy in other lines of human endeavor.

A fourth value is the establishment of a permanent interest, as the basis of future observations. By this I do not mean the establishment of such an interest as will make the students

specialists in botany. Some may become specialists, if the course is properly presented, but it should not be because any part of the purpose beneath the course is to make specialists. The course should establish a general interest in plant life that will be lifelong, in just the same way that other courses of study should establish the same sort of interest within their own field. Broadening of intelligence and making more definite inquiries into surrounding phenomena are no small parts of the reason for existence of the botany course.

Recognizing the conditions existing among high schools, and believing that there is pretty general agreement as to the values to be obtained from a high-school course in botany, it seems that it should be possible to come more nearly to an agreement as to what should be the organization of the course. It would seem that if the course is to be based upon the fact that all plants are performing but two functions, nutrition and reproduction, the sooner that the students obtain some elementary notions of this fact, the more economical will be the work done. As early as possible structures should be interpreted in the light of function. I know of no better way to begin with a class of high-school boys and girls than to select some plant, already known to most or all of them, and to proceed to determine the functions of its different parts. Some general conversation by the students, while having the plant before them, usually will show that they already know the significance of roots, stem, and leaves, though they may not have formulated this knowledge into a definite statement. A few physiological experiments, in whose arrangement some of the students assist, but which are used for demonstration and observation before the entire class, will serve to illustrate the work of roots, stem, and leaves, and will form a basis for an elementary discussion of absorption, conduction, and photosynthesis. This discussion must be quite elementary, it is true, and must avoid many technicalities that some specialists have wished to see introduced, but we must remember that all we wish to do in this connection is to establish a relatively small amount of knowledge of a few essential processes in the plant's solution of the problem

of nutrition, namely, the significance of absorption and of the function of chlorophyll.

Following this work, the leading facts of reproduction may be established readily by planting and studying a few seeds, some slips, sprouts, etc. In this way, or some similar way, there is established the fact that structures exist for the performance of work, and that both structure and work must be studied in order that either may be understood. The amount of such work introduced for the purpose of establishing a notion of the plant's fundamental processes by use of plants best known, may be elaborated profitably if ample time is had for an extended course. In connection with this preliminary work the compound microscope may or may not be used to demonstrate such cellular structures as root-hairs and the epidermal cells from which they grow, and the cells of the leaf that bear chlorophyll. In this way an idea of magnification and its use is introduced. When so introduced, I believe it as simple a matter for students to learn the proper place and use of the microscope as it is to learn the same things regarding balances in a physical or chemical laboratory. So introduced, apparatus becomes, not an end, but means to an end. The student realizes that the microscope as well as other laboratory apparatus is designed to assist in extending and making more efficient his own powers of observation.

Following the introduction of the two general problems of plants, as outlined above, one of three more or less popular plans of courses may be used: first, continuing the physiological experiments and introducing with them considerable ecological work, making the course into that which is ordinarily known as a course in ecology; secondly, considering various aspects of the flowering plants, perhaps closing the course with an extremely brief survey of the lower groups; thirdly, considering the groups in the order of their complexity, ranging from lowest to highest.

Each of these three plans of courses should be tested from the view-point of the values to be sought, as outlined in the second section of this paper. The first or ecological course offers ample opportunity in a study of functions of plants, but

unfortunately, if this study is continued for any considerable length of time, the student finds himself limited because of his lack of knowledge of organs of plants further than the most obvious ones of the plants he has seen all his life. It seems folly to try to study the adaptations of an organ before we have knowledge of what the organ is. At this point the work must become morphological for a time, else conclusion as to functions must be based on insufficient data, hence unscientific. It would seem that any detailed study of the adjustments of plants as a topic in itself should succeed some study of what the plants are. In the best thinking, I believe, we do not make comparisons until we obtain some notions of at least one of the two or more things compared. Logically, it seems to me, after having a general notion as to plant problems, our beginners study structures, and, as they study them, interpret them in the light of their work. Following this comes comparison of these structures with others, and interpretation of the others by means of the facts learned concerning the first group. It is possible definitely to organize this course, but there is considerable doubt as to whether it is possible so to organize it that the beginner will develop the scientific method of thinking so well as will be true if a knowledge of the structures with which he deals should precede detailed work of this sort.

From this course little notion of the evolution of the plant kingdom can be obtained by a beginner, since rather specialized phases of evolution are presented. It is true that if much morphological work is done in connection with the course, some of the simpler phases of evolution of structure may be well presented.

The second plan for a course of study must necessarily present the morphology of seed plants without the vantage ground of knowledge of other groups found below. From a functional and from an evolutionary point of view, is it not far more difficult to understand the structures of seed plants without a knowledge of lower groups, than it is to encounter the much-heralded difficulties associated with a study of the lower groups? From the very nature of the plan of this course, it cannot be logi-

cally organized, and most of the plans presented for such a course attempt no unifying organization for the whole, but present a series of isolated topics. This being true, it would seem that the best educational values cannot come from this course. The plan is the one which, in my opinion, should prevail in the work of the grades.

The third plan should not be a course in morphology, but, from the nature of the subject, morphological considerations should determine the organization of the course. In use of such a plan, organs are always to be looked upon as means of accomplishing work. The gradual stages through which these organs differentiate and become more perfectly adjusted to specific problems are subjects of interest. The comparison of the ways in which plants in various groups, through differentiation of structures, relate themselves to their nutrition and reproduction seems to me to make the best basis for development of the more important values to be had from a course in botany. The student cannot be said to be educated in any sense until he has some facility in detecting likeness and differences. This sort of study, it seems to me, offers the best means of developing this faculty.

Such a course presents the type of working plant body found in each group, and as much of the specialization in the group as time will permit. Physiological, ecological, and classificatory considerations cannot be omitted from such a course, if our basis of nutrition and reproduction, and necessary knowledge of names of type-forms, is kept in mind. The structural element becomes merely the organizing feature of the course, and no less attention is given to real plant work than is true in the course first considered. The entire course, including whatever it may of structure, ecology, physiology, economic uses, etc., becomes an organized unit arranged in the logical order of the plant kingdom itself. I have had some experience with high-school pupils brought up botanically upon the study of disconnected topics having to do with seed plants. Some of them have good notions about some of these topics, but they do not have an adequate conception of the problems or structures of the plant kingdom as a whole. To me a course based upon isolated topics within the seed plants is

like constructing the second story of a house in the position it should occupy, without having the first story, or even any scaffolding. I can see however, how it is entirely possible to construct this second story, and afterwards elevate it to its proper position by building the first story under it. Such a procedure botanically is not uncommon, but must occasion some loss of energy.

I realize that numerous objections may be made against this course I am advocating. It often is represented by work in nothing except pure morphology and anatomy. It is easier for teachers to keep pupils busy in pure morphology and anatomy, or in classification, than in a course that adequately represents botany; consequently the course sometimes suffers such a fate.

Another objection often made is that beginning students, being new to the laboratory and its apparatus, are bewildered by these, together with the additional strangeness of observing plants that must be seen with the microscope. There is an element of truth in the objection, and some time and careful direction are necessary to obviate this disadvantage and establish with the students the proper point of view relative to laboratory apparatus. During the present school year a boy of fifteen said, among other things, in answer to a question as to the work he is doing: "I have botany three days a week and laboratory two days a week." Too often this condition exists; it is not made clear that the laboratory is merely a device for pushing back a little our limitations in observation. But that there needs to be no trouble of this kind for more than one or two days I have seen demonstrated again and again. The teacher sometimes fails to recognize that boys and girls of high-school age cannot be turned loose in a laboratory and expected unassisted to relate themselves to apparatus, as college students might do under similar circumstances.

Furthermore, much of this early laboratory work in many high schools must be of the nature of demonstration work, and thus remove from the student some of the manipulation of material. I do not believe it advisable to remove a great deal of this handling of material, since one of the best immediate results of the laboratory comes from learning to handle materials in a neat and definite way, so as to obtain proper results.

Another objection often presented against this plan of course is that it is hard, and numerous plans have been introduced purporting to give a course that will be much simpler for the student, and incidentally for the teacher too; and I do not doubt that they are so. If the same values can be had from a simpler course, all would readily adopt it; but such does not seem true. The simple courses uniformly consider, in the main, isolated topics illustrated in the highest groups of plants. That the course here advocated is more difficult is not an argument against it. Hard work develops strength. A real knowledge of the scientific method of thinking, of the essential principles of plant life, real culture, comes only through hard work. And I firmly believe that more will be done for high-school students by subjecting them to such a logical, definitely organized course, involving all the leading fields of plant study, teaching the relative evolution of plants of various groups from the points of view of structure, ecology, and physiology combined. The course is one in botany, not one in any specialized field of botany.

Professor B. P. Colton, of the State Normal School at Normal, read a paper from the standpoint of zoölogy, upon

THE PHASES OF ZOÖLOGY THAT NEED TO BE EMPHASIZED IN SECONDARY EDUCATION.

1. We must teach by means of types. We wish the student to get a good general knowledge of the animal kingdom as a whole. From the bewildering array of animals presented by nature the teacher must select a few forms as representatives. From the knowledge gained from these type-forms the student proceeds to reading about related forms. That is, on the basis of real knowledge, gained from actual study of the type, he builds a structure of information through reading and hearsay. This proceeding is based on the doctrine that real knowledge comes only through the senses, and that what we get in other ways is information rather than knowledge. Or, to put it in another way, the knowledge of the type is a peg firmly driven